UDC 666.1.022:666.1.01

AN OBJECT-TARGET ANALYSIS OF THE GLASS BATCH PREPARATION TECHNOLOGY

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Translated from Steklo i Keramika, No. 2, pp. 5 – 6, February, 2002.

A solution of the problem of analysis of glass technologies under modernization, in particular, the technological process of preparation, dosing, and mixing of a glass batch, is considered in the form of an algorithmic sequence of target and object decomposition procedures. The proposed method of object-target analysis makes it possible to study the introduction of new equipment in the technological process or a modification of the regimes of existing equipment by correlating the innovation directly with the targets implement by the equipment and the limitations imposed by the technology.

In the conditions of a dynamically growing market of glass products, manufacturers are forced to continuously improve the technology of glass production. Setting up an effective glass-producing enterprise represents a rather complicated problem due to the fact that machinery, equipment, and automated control devices are nonuniformly distributed among the companies. Consequently, it is logical that glass technologists address the newest methods for studying complex systems, namely, the object-oriented analysis and synthesis methods [1].

The present paper offers a solution for the problem of analyzing technologies of glass production under an upgrade, in particular, the technological process (TP) of preparation, weighing, and mixing of glass batch components, in the form of an algorithmic sequence of target and object decomposition procedures. This method is based on the object-oriented analysis proposed by G. Buch [1] in the object field of technological systems and is complemented by a diagram of target classes [2]. The proposed algorithm of an object-target decomposition makes it possible to investigate a technological system based on the targets of its development and involves the following sequence of procedures: a target diagram is constructed by means of stating the global target of a TP and subsequent decomposition into subtargets based on the criteria of the “target-initiation space” and the main elements of the TP; the target diagram is interpreted as a diagram of target classes; the TP objects are formed as successor classes of the respective target classes; and a diagram of the TP classes, which is the essential structure of the TP, is constructed in the course of the object decomposition.

Let us analyze the procedure of studying innovations in the TP of preparation, dosing, and mixing of glass batch components [3] based on the global target, that is, raising the profitability of this technological cycle. The analysis procedures are illustrated with an object-target diagram of the TP classes.

The main target class of this TP is “Profitability” (Pr). The target function of this class is to increase the profitability of the TP. The arguments of this function are “efficiency” (Ef), “material waste” (WM), and waste in finished product (WP) determined by the batch preparation process. These arguments determine the target classes of the second level. The class of “Site efficiency” (Ef) correlates with the “increase in efficiency” target function, and the arguments of the latter are “the time of preparation of individual components” T_i and the “time of mixing of components” T_{mix}. The “material wasted in batch preparation” (WM) class correlates with “a decrease in waste in batch preparation” target function with its “waste caused by equipment” (WEq) and “waste caused by dust entrainment” (WD) arguments. The “Waste of finished product” (WP) class correlates with “a decrease in the number of defective products” target function with the argument of the “accuracy of the composition” (AcC) of the glass batch with respect to a prescribed formula. The arguments of the target functions of the second level determine the target classes of the third level. The latter correlate with their own target functions, whose arguments are the parameters of the technological regulations of glass batch preparation.

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Target classes and target functions of the TP of glass batch preparation

Class	Target function
Profitability of the TP of glass batch preparation	Increase in the profitability of the production unit $P = f(\mathrm{Ef, WM, WP}) \to \max$
Efficiency of TP	Increase in the efficiency of the production unit $\mathrm{Ef} = f(T_1, T_2, ..., T_n; T_{\mathrm{mix}}) \to \max$
Material waste in batch preparation	Decrease in waste generated in batch preparation $\mathrm{WM} = f(\mathrm{WEq, WD}) \to \min$
Waste in finished product	Decrease in the amount of defective product $\mathrm{WP} = f(\mathrm{AcC}) \to \min$
Time of preparation of an individual glass batch component ($T_1, T_2, ..., T_n$)	Decrease in the duration of the component preparation $T_i = \sum T_{\mathrm{op}\,j} = f(S_{\mathrm{eq}})$; $i \in [1, n] \to \min$, where i is the component index; j is the index of a specific operation involving this component; $T_{\mathrm{op}\,j}$ is the duration of the jth operation in the preparation of the particular component; S_{eq} is the speed of equipment; n is the number of components in the formula
Time of mixing of batch components	Decrease in the time of mixing of the batch components $T_{\mathrm{mix}} = f(S_{\mathrm{mix}}) \to \min$, where S_{mix} is the speed of mixing and transporting
Waste caused by equipment	Decrease in the waste caused by equipment $\mathrm{WEq} = f(x_1, x_2, ..., x_m) \to \min$, where $x_1, x_2, ..., x_m$ are the parameters of the equipment
Waste caused by dust entrainment	Decrease in the waste caused by dust entrainment $\mathrm{WD} = f(S_{\mathrm{eq}}, S_{\mathrm{mix}}, \mathrm{M, DP}) \to \min$, where M is the moisture and DP is the dust protection of the equipment
Accuracy of compliance to the formula	Increase in the accuracy of compliance with the formula $\mathrm{AcC} = f(\mathrm{WM, AcEq}) \to \max$, where AcEq is the weighing accuracy of the equipment

The target classes form the three upper levels of the object-target class diagram of the TP of glass batch preparation. They are interrelated by succession relationships and also by relationships connected with the dependence of different target functions on the same technological parameter. These relationships form restrictions on solving target functions and in subsequent analysis make it possible to identify parametric contradictions between target functions implemented by the equipment or machinery items. The relationships between the target classes of the system of glass batch preparation are indicated in Table 1.

TABLE 1

Relationship number in the diagram	Description of relationship	Formula
1	Time of preparation of a component related to waste in dust entrainment (via the speed of the equipment)	$\begin{cases} T_i(S_{\mathrm{o}}) \to \min \Leftrightarrow S_{\mathrm{eq}} \to \max \\ \mathrm{WD}(S_{\mathrm{o}}) \to \min \Leftrightarrow S_{\mathrm{eq}} \to \min \end{cases}$
2	Time of mixing of components related to waste in dust entrainment (via the speed of mixing and transporting)	$\begin{cases} T_{\mathrm{mix}}(S_{\mathrm{mix}}) \to \min \Leftrightarrow S_{\mathrm{mix}} \to \max \\ \mathrm{WD}(S_{\mathrm{mix}}) \to \min \Leftrightarrow S_{\mathrm{mix}} \to \min \end{cases}$
3	Time of preparation of a component related to the accuracy of its dosing	$\begin{cases} T_i(S_{\mathrm{eq}}) \to \min \Leftrightarrow S_{\mathrm{eq}} \to \max \\ \mathrm{AcEq}(S_{\mathrm{eq}}) \to \max \Leftrightarrow S_{\mathrm{eq}} \to \min \end{cases}$
4	Material waste related to the accuracy of compliance with the formula	$\mathrm{AcC} \to \max \Leftrightarrow \mathrm{WM} \to \min$

The target functions of the respective target classes of the last level are implemented in the environment of the TP equipment, which forms their successor classes. A subsequent object decomposition of the TP is logically predetermined: an object class succeeds a respective target class and forms an equipment class that realizes a target function. It is here that the technological parameters are identified that need to be optimized when the batch preparation technology is modified. This largely depends on a specific TP in the particular production.

Thus, in considering a typical TP of preparation, dosing, and mixing of glass batch components [3], we distinguish three main classes of batch-preparation equipment (Fig. 1): “Equipment for preparation and dosing of components” (Eq), “Transport conveyor belt” (Conv), and “Mixer” (Mix). The “Equipment for preparation and dosing of components” class succeeds several target classes: “Time of preparation of an individual glass batch component,” “Waste caused by equipment,” and “Accuracy of the batch composition.” The target class “Time of mixing of batch components” has two successor classes: “The conveyor belt” and the “Mixer.” A class called the “Doser of a component” (D) is discriminated from the “Equipment for preparation and dosing of components” class and provides for the implementation of the target func-

tions of the three parent target classes listed above. The operating regimes of the dosing units depend on the arguments of these functions and also on the relationships between the target classes.

As can be seen from Table 1, one of the limitations imposed on the general efficiency of the glass batch preparation process is related to waste in the form of dust entrainment. This problem could be solved by upgrading the existent equipment or by installing new equipment. If, for instance, new equipment is introduced, we link the "Equipment for preparation and dosing of components" class via a succession relationship to the "Waste in dust entrainment" target class, and the "Equipment for preparation and dosing of components" class, in turn, forms a new class called "Moisturizers of components" (Mois). The implementation of the target function WD with an argument represented by moisture (M) is observed in the relationship WD – Eq – Mois. An alternative to this solution could be the use of protective sheaths that prevent or decrease the waste caused by dust entrainment. For instance, we can install a protective sheath on the conveyor belt (the "Transport Conveyor belt (Conv) class); accordingly, we introduce a new class named "Sheath" (Sh) that implements the succession relationship of WD – Conv – Sh and solves the target function WD (the newly introduced succession classes and relationships are indicated in bold lines in the diagram in Fig. 1).

Thus, the proposed method of object-target analysis makes it possible to study the possibility of introducing new equipment in a TP or modification of the available equipment regime by directly correlating the innovation with the targets implemented by the equipment and the technological limitations. The description of analysis procedures is given in the context of the object-oriented method and, which is especially important, in the terms of a predictable solution of the object environment of the TP of glass batch preparation. This allows for an effective cooperation between the technologists and the equipment engineers in the course of analysis of the technology, which contributes to a successful solution of the problems of upgrading the process of glass production.

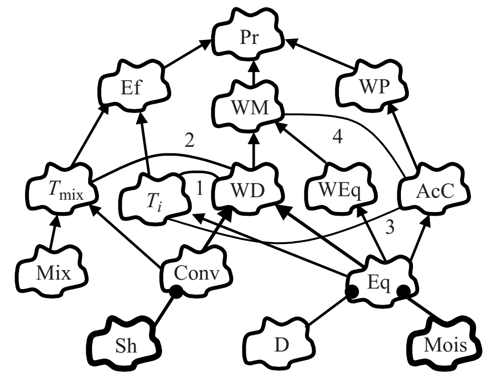

Fig. 1. Diagram of classes of the TP of glass batch preparation.

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